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A review of the Onychophora of South Africa, with discussion of their conservation

by

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ABSTRACT

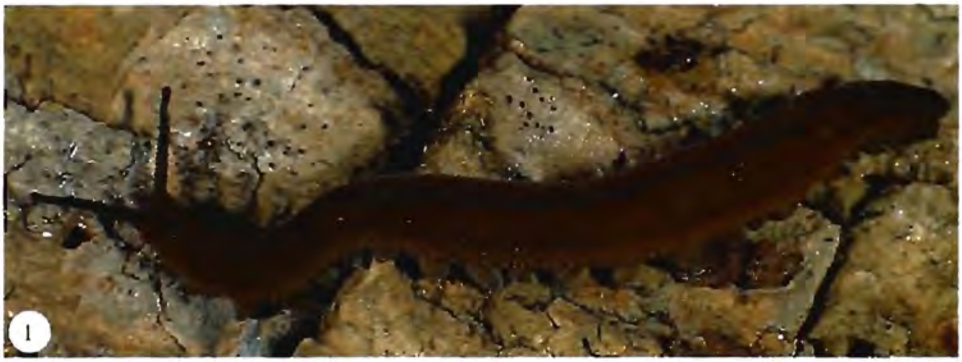
There are nine described species of Onychophora (Peripatopsidae) in South Africa, two in *Opisthopatus* Purcell, 1899 and seven in *Peripatopsis* Pocock, 1894. These species are redescribed, illustrated and keyed to facilitate future ecological and biodiversity studies. The nine species almost certainly form an incomplete list, as it appears that there are at least another five undescribed species. Taxonomic investigations using molecular techniques and scanning electron microscopy will almost certainly also reveal many new species, these currently confused with described taxa. Information on the biology, phylogeny and possible species diversity of South African Onychophora is also given. Conservation of these onychophorans is discussed, and recommendations made for the new IUCN Categorisation of the threatened species: *Opisthopatus roseus* Lawrence, 1947 (VU), *Peripatopsis alba* Lawrence, 1931 (VU), P. *clavigera* Purcell, 1899 (lc) and *P. leonina* Purcell, 1899 (CR). Suggestions for conservation management and legal protection are also given.

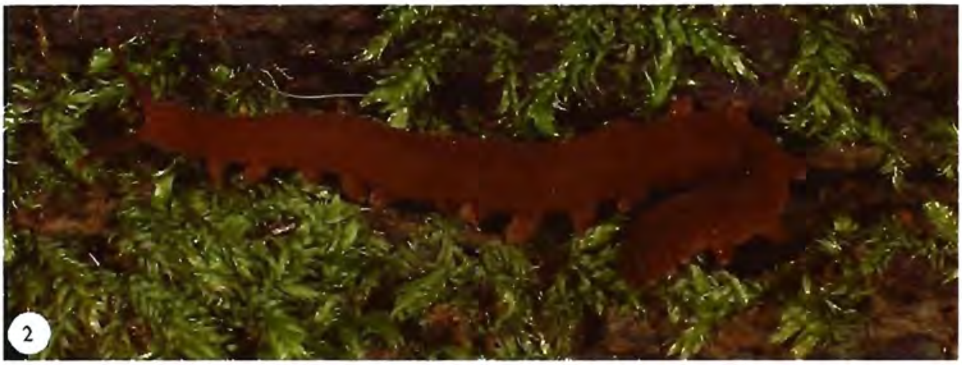
INTRODUCTION

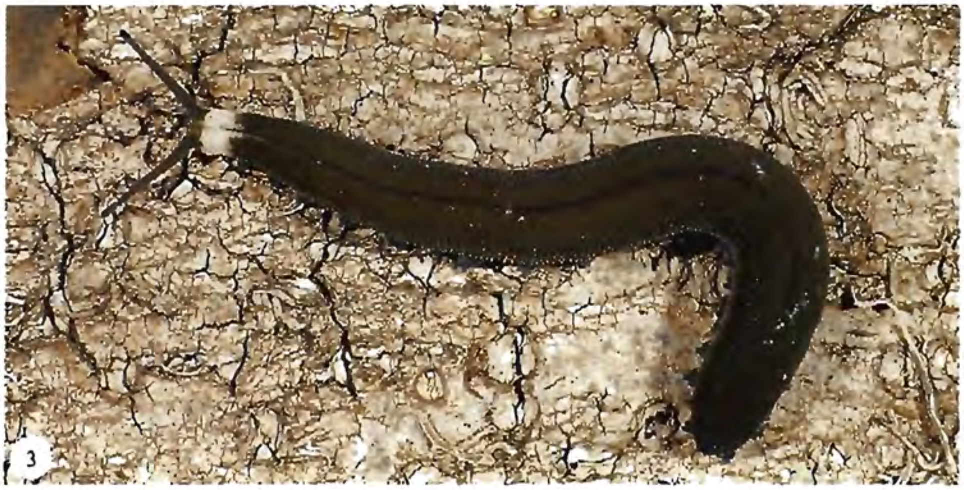
The South African onychophoran species have been relatively well studied, but publication of most data has been scattered in inaccessible scientific journals; the most recent research on the taxonomy of the regional fauna was published in German by Ruhberg (1985). The aims of this paper are to produce a synthesis of available data, to facilitate and stimulate further research. Towards this aim this work includes species descriptions, which will allow non-specialists to identify the South African species, and data on species distributions and habitats. In addition, the conservation of South African onychophorans is discussed.

MATERIALS AND METHODS

The data presented here were mostly obtained from the literature. Illustrations were prepared from museum specimens. Localities were derived from the literature or from specimens housed in the South African Museum (Cape Town), the Natal Museum (Pietermaritzburg), and the Transvaal Museum (Pretoria). Each locality is presented with the most recent date of collection. In cases where the date of collection is not known, the date of the reference is given and marked by an asterisk, but if the record has not been published, the locality is followed by a question mark.







Figs 1–3. Colour variation in South African onychophorans. 1. *Peripatopsis moseleyi* (Wood-Mason, 1879). 2. *Opisthopatus roseus* Lawrence, 1947. 3. *Peripatopsis moseleyi*, collared form. [Photographs: Dr D. G. Herbert.]

THE SOUTH AFRICAN FAUNA

All South African onychophorans belong to the family Peripatopsidae which has a total of 36 genera, the majority of which occur in Australia (Reid 1996). Two genera are present in South Africa; *Peripatopsis* (7 described species) and *Opisthopatus* (2 species). The general external and functional morphology of all approximately 200 onychophoran species is basically similar. The two South African genera are differentiated on the basis of the size of the last pair of legs, and the position of the distal papillae of the feet (Fig. 4). The number of legs is of some importance since the number does not vary intraspecifically in *Opisthopatus*, but does in *Peripatopsis*.

Additional intergeneric differences between *Peripatopsis* and *Opisthopatus* include patterns of embryonic development (see Walker 1992, 1995). All South African Peripatopsidae are ovoviviparous (Campiglia & Walker 1995). In *Peripatopsis* each female contains up to 20 embryos, all at more or less the same stage of development and all the young are born over a definite, short period (Manton 1938*b*). Embryonic development takes 12–13 months. In *P. capensis* and *P. balfouri* the fertilised eggs pass into the oviduct in April and they give birth over a few weeks in May and early June of the following year. In the Eastern Cape, *P. moseleyi* gives birth from June to December, but most young are born before mid-October; in KwaZulu-Natal this species gives birth in March and April (Holliday 1944). In *Opisthopatus cinctipes* there are up to 40 embryos at different stages of development and young are produced throughout the year (Purcell 1899). The young of both *Peripatopsis* and *Opisthopatus* are born alive, one or two at a time, tail first. They resemble the adult in all respects except for colour and size. Sexual maturity is reached in both sexes after about 9–11 months in *P. moseleyi*. In *P. balfouri, capensis, sedgwicki* and *moseleyi* the female gives birth to the first batch of young when she is about two years old. Fertilisation of the next batch of eggs takes place about a month before the previous embryos are born. The maximum size is reached after about 3 years, and the life span is about 6–7 years (Manton 1938*b*). South African onychophorans moult at about two-week intervals.

In terms of behaviour the genera also differ; in KwaZulu-Natal and the Eastern Cape *Opisthopatus cinctipes* curls up when disturbed (Fig. 10), while the sympatric *Peripatopsis moseleyi* does not.

The distinction of the South African onychophoran species is based largely on the number of legs, the size of the last pair of legs and whether the latter are clawed or not. The shape of the dorsal body papillae and the relative thickness of the spinous foot pads on the ventral surface of the legs (Fig. 4) also have some taxonomic value. There is some intraspecific variation in the density and the degree to which papillae are developed in most species. Colour is of limited use as a taxonomic character; it varies within species, there is much overlap in coloration between species, and pigments are not always well preserved.

Purcell (1900) recognised four basic colour patterns for the South African species, but all specimens examined by him included forms having a dorsal and lateral surface ground colour ranging from deep, velvety black to greenish black, to light green and to light brick-red (Fig. 1). Two species discovered after Purcell's (1900) publication can be recognised on the basis of colour: *O. roseus* is a uniform reddish pink (Fig. 2),

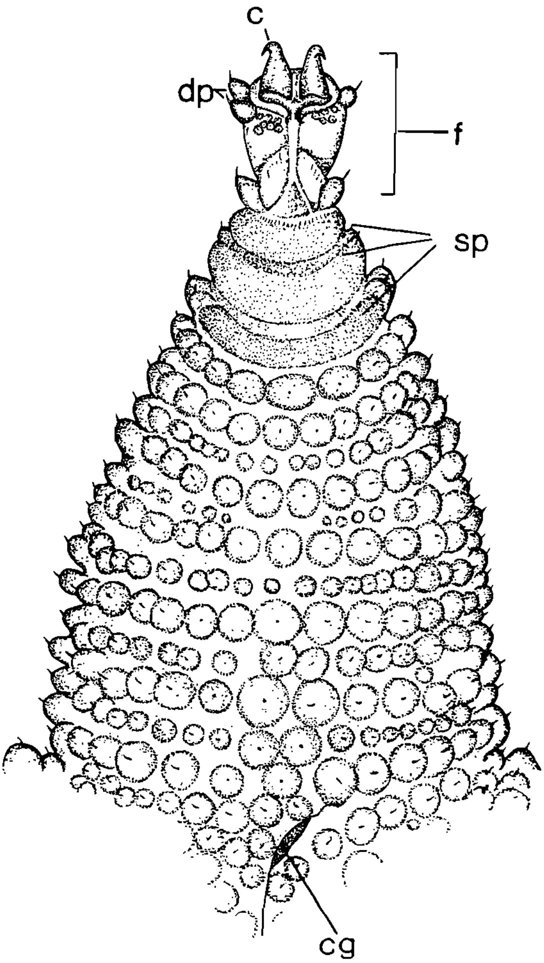


Fig. 4. *Peripatopsis*, ventral surface of leg, showing structure of this appendage and terminology used in text. c = claw; cg = coxal gland; dp = distal papillae; f = foot; sp = spinous pads.

but is an off-white colour when preserved, and *P. alba* is white. Collared forms, which have a brown or black upper surface with a band of white encircling the head and covering the oral papillae and parts of the first pair of legs, have been recorded in three *Peripatopsis* species (Fig. 3). Similar colouring has also been recorded in representatives of Peripatidae from the neotropics and is not thought to indicate separate species (Peck 1975).

Species relationships, biology and distribution

Phylogenetic relationships are difficult to determine. Monge-Najera (1995) hypothesised that the separation of the South African peripatopsids has an early Cretaceous date. Allozyme data (Walker 1995) indicate that the two South African genera shared a common ancestor about 30 million years ago and that two

Peripatopsis species (*P. capensis* and *P. sedgwicki*) diverged about 13 million years ago. It seems likely that the two species, *P. alba* and *P. leonina*, which inhabit restricted areas of the distributional range of *P. balfouri*, are close relatives of this species (Brinck 1957).

The distribution of onychophorans in South Africa corresponds with the regions in which discontinuous indigenous forests occur, but there are a few localities outside such regions (for example in the Cedarberg Mountains and Dunbrody), although indigenous forests could have previously occurred in these areas. The absence of onychophorans from the eastern forests of Zimbabwe was explained by the barrier formed by the dry Limpopo in recent times (Brinck 1957). The collection of onychophorans from northern Mozambique could, however, negate this hypothesis.

South African onychophorans most commonly live in forests or in bushy ravines along mountain slopes. According to Brinck (1957) isolation of many populations is effective and many of the gaps are caused by deforestation and land destruction by humans. Endrödy-Younga & Peck (1983) reported large numbers of *Peripatopsis* in grassveld and open fynbos habitats several kilometres away from typical habitats. In the Cathedral Peak area of the Drakensberg, *P. moseleyi* was collected under stones in grassland, while in the Langeberge region of the Cape, *P. capensis* was found in non-shrubby fynbos. It was evident that these populations were avoiding dehydration by vertical movements in the soil, and selecting depths where conditions were favourable. The occurrence of onychophorans in savannah and open canopy forests is known in Australia, Jamaica and Brazil (Endrödy-Younga & Peck 1983). These populations have not become adapted to harsher environments, but rather avoid them through selecting milder microhabitats. Endrödy-Younga & Peck (1983) suggest that humans are not responsible for all deforestation and this is often the result of climatic changes. They suggest that the current distribution of onychophorans in South Africa could only have occurred by dispersal if the area in the Cape occupied by them, or at least routes connecting present distributions, were forested at one time. The grassland populations, therefore, are true relicts from previously-forested areas. In the case of the fynbos species however, open conditions may always have been utilised.

As with many other old Cape faunal elements, the largest number of species occur in the south of the Western Cape – especially the Peninsula – and in the Knysna area (4 species each). Brinck (1957) pointed out that during the greatly varying climatic conditions of the Tertiary, the southwestern Cape has, at various times, served as a refuge for large numbers of plant and animal species which otherwise would have become extinct. It is possible that *Peripatopsis* originated in the southern parts of the Western Cape and is primarily a temperate genus, while *Opisthopatus* is a subtropical genus which originated in southeastern refuges in the Eastern Cape and KwaZulu-Natal.

Onychophorans are unable to withstand desiccation, and thus avoid dry environments. The reason for this vulnerability is the inability to close the large number of tracheal spiracles which are scattered over the exocuticle (Manton & Ramsay 1937). It is possible that 33 % of onychophoran body mass can be lost by desiccation in a three and a half-hour period, and that desiccation beyond this is fatal (Bursell & Ewer 1950). Eversible sacs situated ventrally at the base of the legs may be responsible for water reabsorption in *O. cinctipes*. In *Peripatopsis*, similar, but non-eversible sacs are found and these are not as effective at water reabsorption (Alexander & Ewer 1955). This difference may explain the wider distribution of *O. cinctipes* in dry areas than *Peripatopsis* (Newlands & Ruhberg 1978). As a result of their vulnerability to dehydration, onychophorans are sensitive to light and are most active at night.

In the three South African species of *Peripatopsis* which have been studied, small white spermatophores are deposited by the male anywhere on the skin of the female where they cause a reaction. Haemocytes invade the point of contact and break down the cuticle and spermatophore envelope, allowing the entry of sperm into the haemocoel and subsequently the ovarian lumen, where fertilisation occurs (Manton 1938*b*,*c*).

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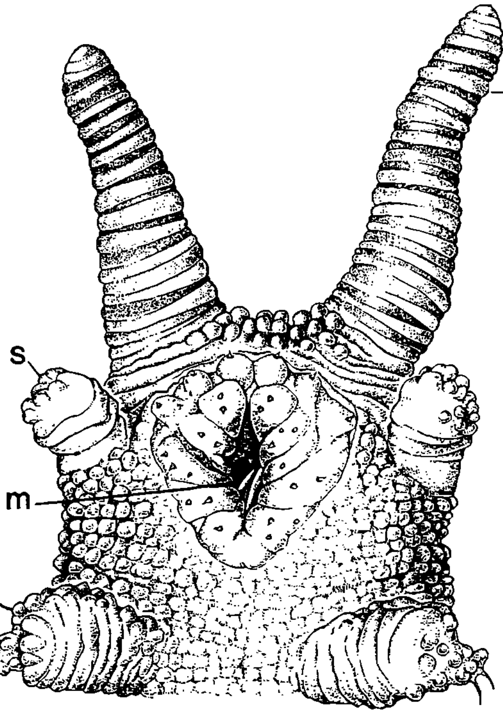

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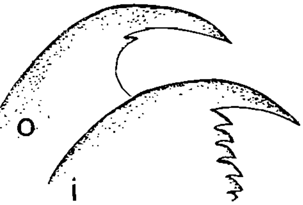

Figs 5–6. Onychophoran head structures. 5. Ventral surface of head region. a = antenna; l = first clawed leg; m = mouth surrounded by fleshy lips (part of the jaws can be seen in mouth opening); s = slime papilla. 6. Detail of the inner (i) and outer (o) jaws of a peripatopsid.

Onychophorans feed on small invertebrates including isopods, crickets, grasshoppers, termites and beetle larvae. When irritated, they shoot out a sticky substance from the slime papillae on either side of the head (Fig. 5). This slime is an effective deterrent against predators, and also helps in trapping prey. Once immobilised by the slime, the prey item is ripped open with the large-toothed jaws

(Fig. 6), digestive juices are pumped into the opening and the soft parts of the prey are sucked up by the mouth, or the prey tissue is sliced up by the jaws and the slices are swallowed.

Excretion of nitrogenous wastes is done to a small extent through nephridia, but uric acid is excreted mainly by the intestine. A chitinous peritrophic membrane is rapidly formed on a daily basis, and shrinks to form a tube lying along the intestine for 18 hours. The membrane is evacuated through the anus, thereby removing all solid waste from the intestinal lumen (Manton 1937).

KEY TO SOUTH AFRICAN ONYCHOPHORAN SPECIES[1]

1 Distal leg papillae arranged as follows: 1 anterior, 1 posterior and 1 median. 16–18 pairs of legs, the last pair well developed (**Opisthopatus**) 2
– Distal leg papillae arranged as follows: 2 anterior, 1 posterior. 16–25 pairs of legs, the last pair reduced (**Peripatopsis**) 3

2 16 pairs of legs, colour variable .... **cinctipes**
– 18 pairs of legs, colour reddish pink .... **roseus**

3 Last pair of legs rudimentary and unclawed 4
– Last pair of legs shortened, with claws 5

4 17–18 pairs of legs with claws, + 1 unclawed, rudimentary pair .... **capensis**
– 19–24 pairs of legs with claws, + 1 rudimentary, unclawed pair .... **moseleyi**

5 Eyes absent; body unpigmented, troglobiont .... **alba**
– Eyes present; body pigmented 6

6 17 (occasionally 18) pairs of legs with claws. Dorsal papillae mostly club-shaped .... **clavigera**
– 18–24 pairs of legs with claws. Dorsal papillae conical 7

7 18 (occasionally 19) pairs of legs with claws .... **balfouri**
– 20–24 pairs of legs with claws 8

8 20 pairs of legs .... **sedgwicki**
– 21–24 pairs of legs .... **leonina**

SPECIES DESCRIPTIONS[2]

Unless stated otherwise, the external morphology of the two sexes is very similar. In *Opisthopatus* the shape of the external genital opening differs in males and females (Fig. 11). *Peripatopsis* males can be distinguished by a white, non-retractile papilla on the ventral surface of each of the penultimate pair of legs.

Opisthopatus Purcell, 1899

Type species: *Opisthopatus cinctipes* Purcell, 1899.

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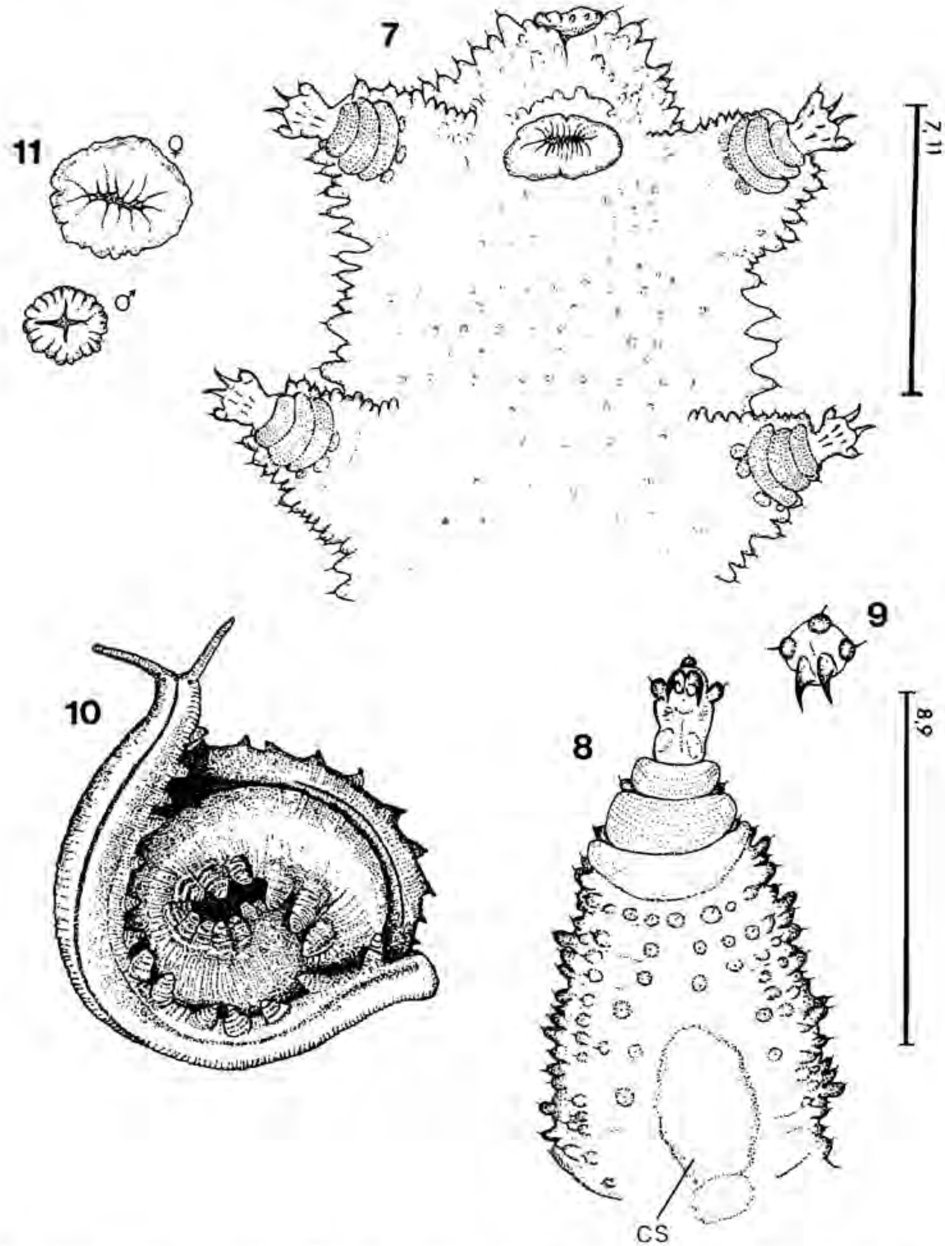
[1] Modified from Purcell (1900), Lawrence (1931) and Ruhberg (1985).

[2] Modified from Purcell (1899 1900), Lawrence (1931 1947) and Ruhberg (1985).



Figs 7–11. *Opisthopatus cinctipes* Purcell, 1899. 7. Posterior region of body, ventral view, showing similar-sized penultimate and last pairs of legs. 8. Ventral view of leg (cs = eversible coxal sac). 9. Dorsal view of foot showing 1 anterior, 1 median and 1 posterior distal papillae. 10. Spiralling behaviour characteristic of both species (redrawn from Lawrence 1953). 11. Genital openings. [Scale lines = 1 mm].

Opisthopatus cinctipes Purcell, 1899

Figs 7–12

Description: Size range (mm): length – female 7–50, male 6–36; width – female 1–5, male 0.8–4. Colour: very variable. Common colour form with slate-grey (turning green in ethanol) dorsum, black midline and mottled appearance resulting from orange-brown main papillae. Ventrum bright pink, or grey. Specimens with uniform rather than mottled slate-grey dorsal surface, bright green or green with reddish head region described. Legs: 16 pairs, middle foot pad 2–3 times wider than proximal one. Fourth pad occasionally present. Last pair of legs fully developed, as long as first pair, and with foot pads and claws (Fig. 7).

Behaviour: Spiralling behaviour known (Fig. 10).

Distribution: Eastern Cape from Port Elizabeth in the south to Mpumalanga in the northeast and bounded by the Great Escarpment in the west. Localities range from sea level to the Drakensberg mountains (Fig. 12).

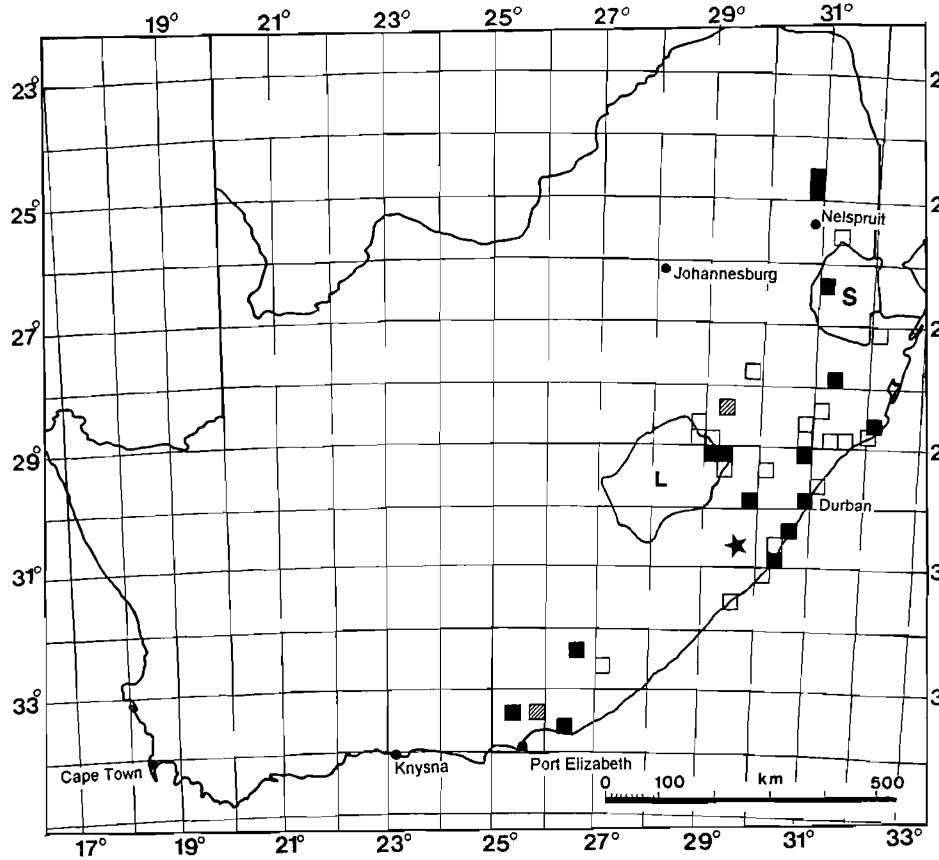


Fig. 12. Distribution of *Opisthopatus*. Squares represent *O. cinctipes* Purcell, 1899. Collection dates: ▨ = pre-1920; □ = 1920–1960; ■ = 1960–present. *O. roseus* Lawrence, 1947= ★. [L = Lesotho; S = Swaziland.]

Localities: **Eastern Cape**: Alicedale (?); Alexandria Forest (1974); Dunbrody, near Blue Cliff Station, Uitenhage (type locality) (1898); Grahamstown (1956); Hogsback (1936); Katberg forest (1961); Port St Johns (1945); Zuurberg Mts (1962). **KwaZulu-Natal**: Bulwer (1936); Compensation (1935); Donnybrooke (1996); Drakensberg: Cathedral Peak (1944), Cathkin Peak (1943), Champagne Castle (1960), Giants Castle (1939), Indumeni Forest (1960), Mont-aux-Sources (1946), Royal Natal National Park, Tugela Valley (1951); Durban: Bluff (1913), Moseley and Northdene (1977); Elandskop, Inkluzaan Mt. (1960); Eshowe (1935); Hluhluwe Game Reserve (1957); Ingwavuma (1938); Inhlazatshe (1961); Kranskop (1954); Liliane near Kranskop (?); Lundie's Hill near Bulwer (1957); Newcastle, Mullers Pass (1947); Ngome Forest (1995); Ngoye Forest (1957); Nkandhla Forest (1935); Nottingham Road, Lion's Bush (1955); Nseleni Nature Reserve (1995); Pennington (?); Pietermaritzburg: Bisley (1995), Hilton Road (1905), Town Bush (1979), Winterskloof (1995); Pinetown (1942); Port Edward (1943); Port Shepstone, beach terminus (1945); Qudeni Forest (1953); Richards Bay (1943); Richmond (1947); Scottburgh (1942); Trafalgar (1963); Umhlali (1957); Van Reenen (1918); Vernon Crooke's Nature Reserve (1992). **Mpumalanga**: Barberton (1939); Blyderivierspoort Nature Reserve (1960); Pilgrims Rest, Mariepskop Forest and Graskop Forest (1960). **Swaziland**: Mbabane (1964).

Habitats: Has been collected from suburban gardens, from wattle and pine forests and from grasslands. Indigenous habitats include *Podocarpus* and *Barringtonia* forests.

Subspecies: Has been divided into three subspecies, namely *natalensis* Bouvier, 1900, *amatolensis* Choonoo, 1947, and *laevis* Lawrence, 1947. These subspecies were distinguished by coloration and 'smoothness of skin', but their distribution is not allopatric, and specimens with the coloration of two subspecies can occur in the same population. The subspecies are, therefore, currently considered invalid (Ruhberg 1985).

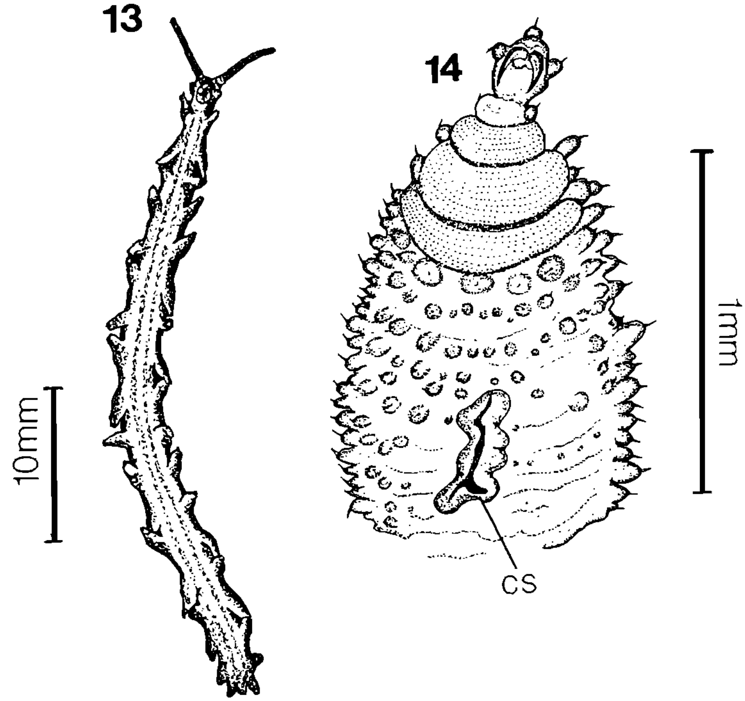
Opisthopatus roseus Lawrence, 1947

Figs 2, 12–14

Description: Size: fully extended (drowned) specimens 42 mm long, 3.5 mm wide. Colour: dull red/dusky rose-red (Fig. 2). Colouring uniform, but legs and ventrum lighter. Integument: Papillae more numerous and close-set, with less variation in size and smaller than in *O. cinctipes*. Main papillae low and rounded, on dorsal surface of body arranged in more regular rows than in *O. cinctipes*. Legs: 18 pairs (Fig. 13), with last pair very little reduced.

Distribution: **KwaZulu-Natal**: Ingeli Forest, *ca.* 35 km E. Kokstad (Fig. 12). Collected July 1945 by R. F. Lawrence. According to Ruhberg (1985), Lawrence had subsequently visited Ingeli Forest a number of times and had searched for additional specimens, but only found one more specimen in 1985 (now in the collection of the Hamburg University Museum). Two specimens were found in 1951, and an additional six were collected in June and November 1995.

Habitat: Lawrence (1947) found the type series in a single group forming a fairly



Figs 13–14. *Opisthopatus roseus* Lawrence, 1947. 13. Ventral view of animal redrawn from photograph in original publication. 14. Ventral view of leg (cs = eversible coxal sac).

tightly packed cluster, under rotting wood. The most recent specimens collected were in 16 cm deep leaf litter, and in litter on a shady bank in the forest.

Peripatopsis Pocock, 1894

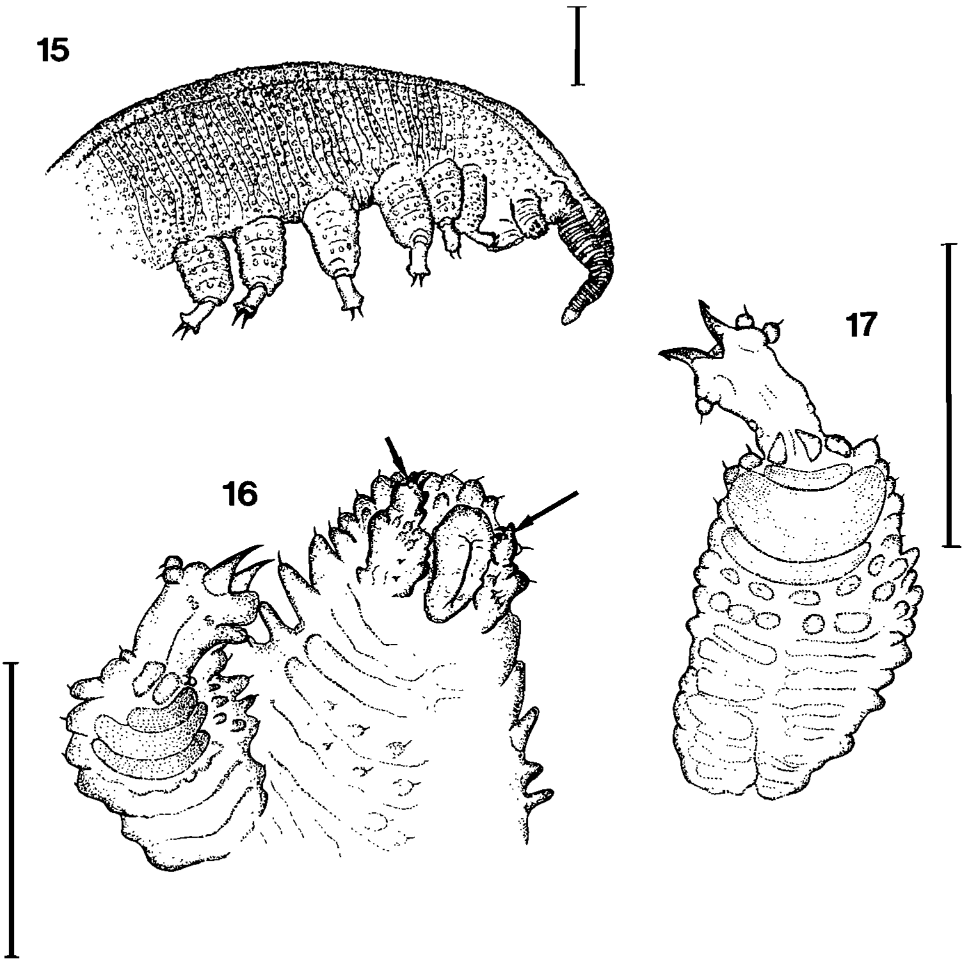
Type species: *Peripatopsis capensis* (Grube, 1868).

Peripatopsis alba Lawrence, 1931

Figs 15–17, 27

Description: Size (mm): length (drowned type specimens) – female 32, male 48; width – female 5, male 6. Colour: white, claws dirty white tipped with brown. Dorsal surface midline a thin opaque stripe running from anterior end of head to slightly before posterior end of body. Eyes completely absent (Fig. 15). Integument: Main papillae conical, with granular appearance. Legs: 18 pairs clawed, last pair much reduced but with distinct claws (Fig. 16). Penultimate pair of legs in male smaller than preceding pair. Middle pad of legs 2–3 times as broad as proximal pad. Foot elongated, and legs distinctly longer and more slender than in other closely related species (Fig. 17).

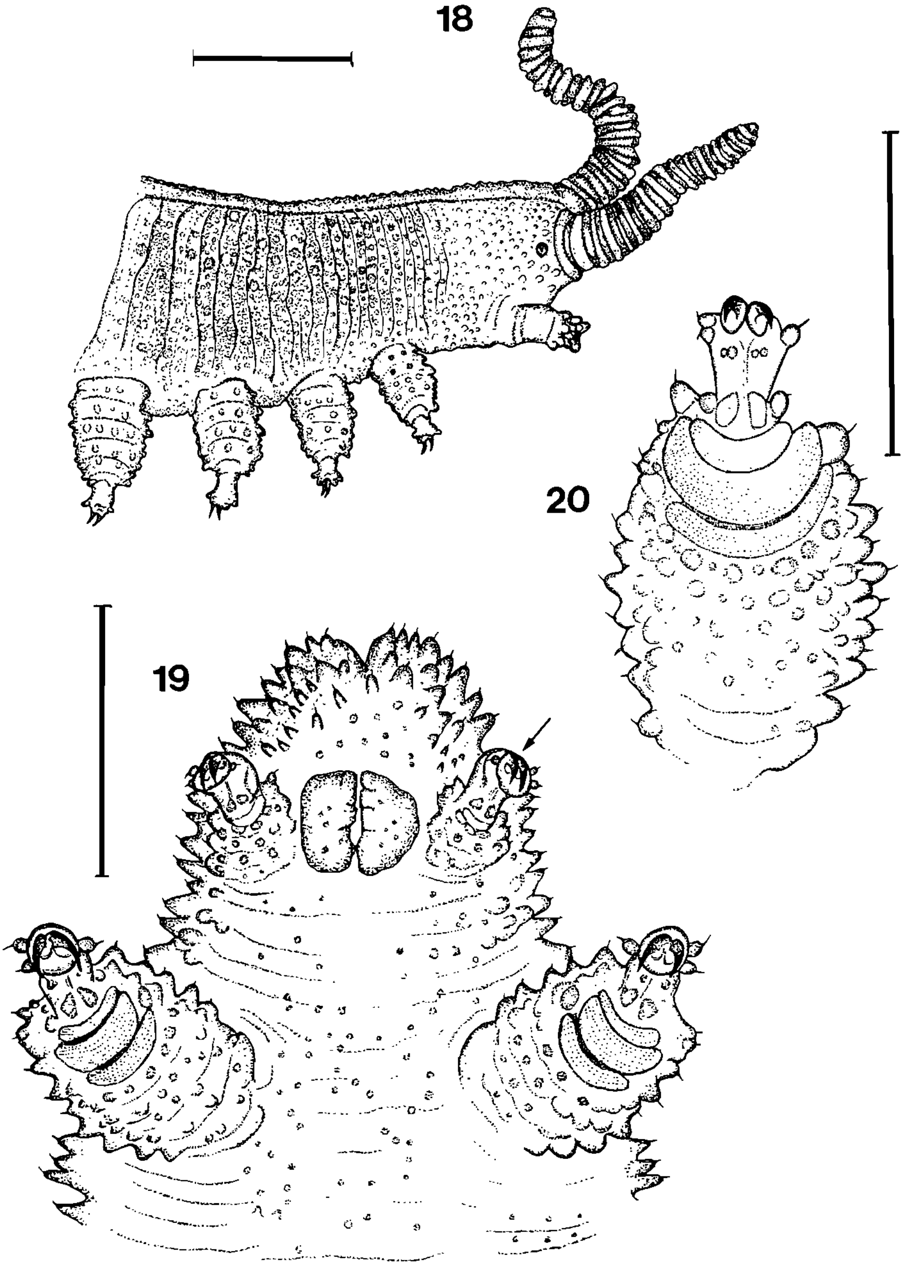
Distribution: **Western Cape**: Table Mountain, Wynberg Cave system (Fig. 27). This species is unquestionably very rare, although N. Sharratt (*pers. comm.*), after



Figs 15–17. *Peripatopsis alba* Lawrence, 1931. 15. Lateral view, anterior region of body, showing longer legs and feet than other species and the absence of eyes (the antennae are also longer, but are here contracted). 16. Ventrolateral view, posterior region of body (last pair of much reduced, clawed legs are indicated by arrows). 17. Ventral view of leg. [Scale lines represent 1 mm].

repeated searches in the winter, finally located two specimens in August and November 1995.

Habitat: The Wynberg caves are deep and labyrinthine. The main gallery, where Lawrence collected some of the type specimens, is about 30 metres below the surface. The walls of the cave are constantly damp from water seeping through fissures in the rocks, and the caves are in total darkness. The only vegetation is a small greyish litchen. Lawrence (1931) found that two specimens of *P. alba* kept under conditions suitable for the survival of the closely-related *P. balfouri*, died 24 hours after being removed from the cave. Sharratt's specimens (*pers. comm.*) were located on moist soil in a very humid section of the cave, and in a very moist fissure in the sandstone.



Figs 18–20. *Peripatopsis balfouri* (Sedgwick, 1885). 18. Lateral view, anterior region of body. 19. Ventral view, posterior region of body, showing reduced last pair of clawed legs (right one indicated by arrow). 20. Ventral view of leg. [Scale lines represent 1 mm.]

Relationships: The similarities between *alba* and *balfouri* were noted by Lawrence (1931) and Brinck (1957). The two species have the same number of legs and very similar integumentary structures, and differ only in colour, presence of the eyes and the length of the legs (Figs 15–20). *P. balfouri* lives just outside the cave on Table Mountain, where *P. alba* has been collected.

The only other cave-inhabiting species of onychophoran is a peripatid from Jamaica, *Speleoperipatus spelaeus* Peck, 1975. This species is also eyeless, unpigmented and has longer legs and antennae than usual.

Peripatopsis balfouri (Sedgwick, 1885)

Figs 18–22

Description: Size range (mm): length – female 8–43, male 8–32; width – female 1.5–5, male 1.5–3.5. Colour: living specimens: dark olive green to almost black (rarely reddish) with 5 dark, longitudinal stripes (a dorso-median stripe divided longitudinally by a thin white stripe, and 2 broad and ill-defined lateral stripes on each side). Speckling, if present, formed by regular rows of bright orange main papillae. A white collar may be present. Ventrum white, sparsely speckled with green. Foot pads yellowish green, feet blue-grey dorsally, black-grey ventrally. Specimens from Simonstown with pale pinkish or bluish ventrum and orange-red head; specimens without orange pigment dorsally and laterally, reported from St James. Preserved specimens: Orange pigment lost, appearing white, ground colour green to blackish. Legs: Male and female with 18 (occasionally 19) pairs clawed legs. Last pair of legs reduced (to a greater extent in male than in female), either without foot pads, or with one indistinct pad, and with a well-developed pair of claws (Fig. 19). Middle foot pad broad: 2–3.3 times as wide as proximal pad (Fig. 20). Integument: Main papillae conical or cylindrical.

Behaviour: Curls up spirally.

Distribution: Western Cape (southern parts) (Figs 21–22). In 1885 Sedgwick collected more than 300 specimens from Table Mountain, the type locality, and Manton (1938*a*) found that it was the most common species in the Cape Peninsula in 1933.

Localities: **Western Cape**: Cape of Good Hope Nature Reserve, Booi se Skerm (1995); Cedarberg, Boschkloof Waterfall (1897*); Diep River (1900*); Kalk Bay (1897*); Mowbray (1874); Newlands (1967), Plumstead (1900*); Riviersondereind (1928*); Simonstown (1899); Stellenbosch, Jonkershoek Valley (1928*); Swellendam (1931*); Table Mountain: Bat's Cave (1960), Camps Bay ravines (1899*), Echo Valley (1950), Hout Bay (1951), Kirstenbosch (1960), Orangekloof (1933), Platteklip Gorge (1981), Window Gorge (1933), Wynberg Cave Ravine (1950); Wilderness (1928*).

Habitats: On Table Mountain habitats recorded by Brinck (1957) were: 'under water soaked moss on wet rock wall; among vegetable debris in wet ravine shaded by indigenous bushes and trees; in rotten log with very wet and loose wood'.

Peripatopsis capensis (Grube, 1866)

Figs 23, 26–27

Description: Size range (mm): length – female 9–70, male 6–54; width – female 3–7, male 1.6–6. Colour: living specimens: greenish or bluish black to black (seldom reddish), with 5 indistinct longitudinal stripes. Speckling, if present, as a result of

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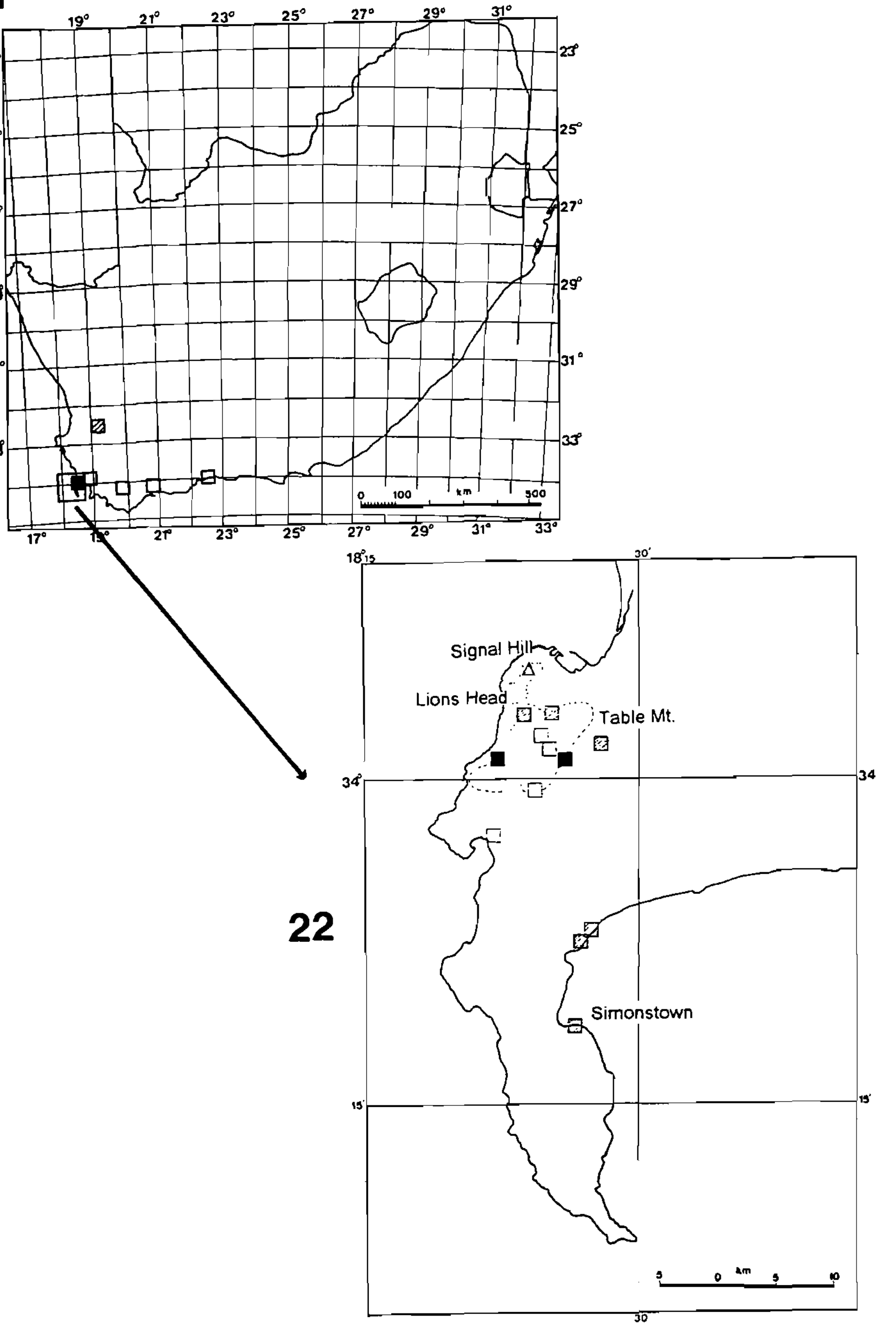
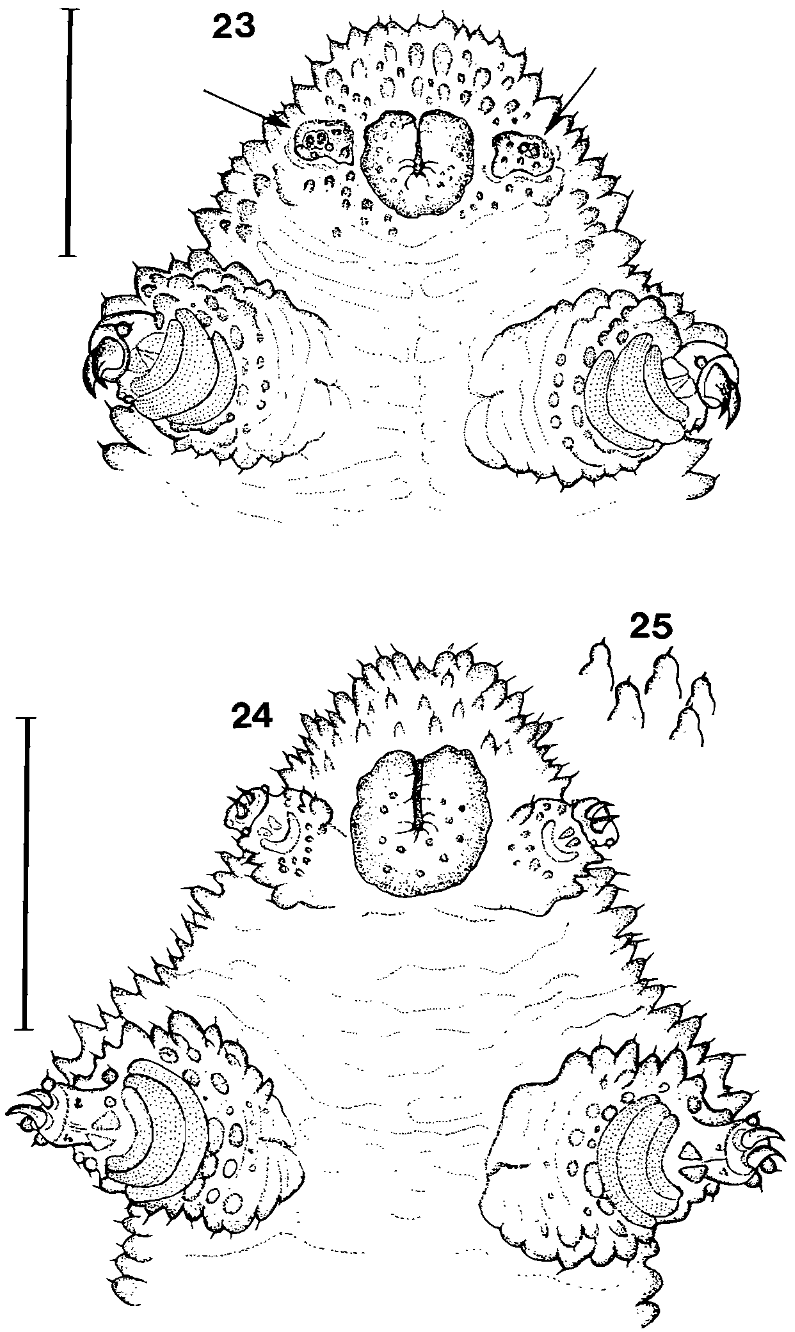


Figs 21–22. Distribution of *Peripatopsis* species in South Africa. 21. *P. balfouri* (Sedgwick, 1885). 22. Detail of Cape Peninsula, showing collection localities of *P. balfouri* (squares) and *P. leonina* (triangle). Collection dates: pre-1920 = ▨; 1920–1960 = ☐ ; 1960–present = ■. Dotted lines indicate Signal Hill and Lions Head (small area) and Table Mountain (larger area).



Figs 23–25. *Peripatopsis* species. 23. *P. capensis* (Grube, 1866), ventral view, posterior region of body, showing last pair of clawed legs and rudimentary, unclawed legs (indicated by arrows) on either side of genital opening. 24. *P. clavigera* Purcell, 1899, ventral view, posterior region of body, showing reduced last pair of legs. 25. Detail of dorsal main papillae, showing characteristic club-shape. [Scale lines = 1 mm].

orange papillae. Legs blue-black and lighter than dorsal surface of body, with orange papillae. Ventrum generally pale orange, frequently sprinkled with blue-black and legs bright orange. Foot pads yellowish green, and proximal pad sometimes orange. Specimens also known with dorsal ground colour orange-red or brown, often with 5 dark red stripes, blue-black feet and bright red ventrum. Integument: Papillae bluntly conical or subcylindrical. Legs: Both male and female with 17 clawed pairs + 1 unclawed pair (occasionally 18+1) of legs with 3 (seldom 4) pads, middle pad 1.4–2 times as broad as proximal pad. Last pair of legs strongly reduced, without claws or pads (Fig. 23).

Behaviour: Does not spiral.

Distribution: Confined to the southern parts of the Western Cape (Figs 26–27).

Localities: **Western Cape**: Boesmansbos Forest above Grootvadersbos (1975); Cedarberg (1972); Constantia (type locality) (1899*); Diep River (1900*); Franschhoek Bos Reserve (1951); Hottentots Holland Mountains, Caledon (1900*); Houw Hoek (1900*); Kirstenbosch (1938); Lamotte Forest Station (1985*); Langeberg, Grootberg (1979); Mowbray (1874); Newlands (1898*); Orange Kloof (1933); Plumstead (1900*); Riviersonderend (1928*); St James (1899*); Swellendam (1958); Table Mountain, Rhodes Memorial (1976); Jonkersberg, Attagua Mountains (1985*); Venster Ravine (1900*); Wynberg (1899*).

Habitats: This species inhabits the forests and bushy ravines of mountain slopes and surrounding lowland. Specimens have been collected 'under stones' and 'under pine log in heavily burnt ground' (Brinck 1957).

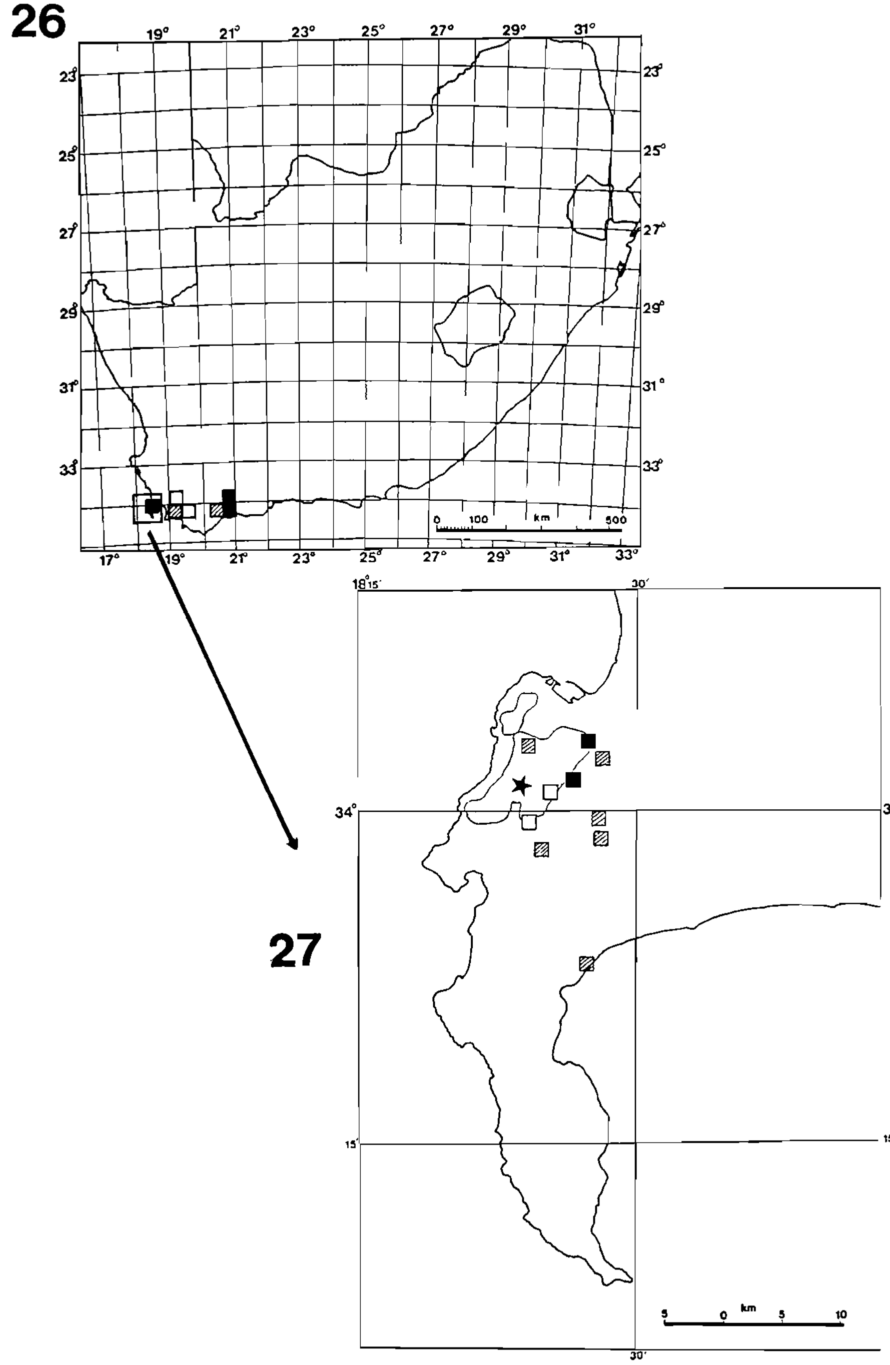
Peripatopsis clavigera Purcell, 1899

Figs 24–25, 28–29

Description: Size range (mm): length – female 7–52, male 7–36; width – female 2–5, male 2–4. Colour: live specimens: dorsal surface medium to dark brown with black mid-line and orange-red, mostly brown-tipped papillae. Ventrum and inner surface of legs pink. Antennae dark brown to black and spinous foot pads bright green. Some specimens with lighter pigmented band of orange-red colour in region of slime papillae. Preserved specimens: Dorsal surface green to dark green with some brown pigment. Legs: Male and female with 17 (occasionally 18) pairs clawed legs. 3 (seldom 4) foot pads, middle one very broad; 2.3–3.6 times as broad as proximal pad. Last pair of legs reduced but with claws and, at most, 1 pad (Fig. 24). Integument: Main papillae distinctly club-shaped or clavate on dorsal surface (Fig. 25). Similarly shaped papillae found in *O. cinctipes*.

Distribution: Restricted to a small part of the northeastern region of the Western Cape (Figs 28–29).

Localities: **Western Cape**: Diepwalle Forest Reserve (1926); Garden of Eden (1975); Kranshoek, Harkerville State Forest between Knysna and Plettenberg Bay (1984); Saasveld near George (1938); Swart River, between George and Knysna (1960). **Eastern Cape**: Tsitsikamma Forest near Storms River (1960).



Figs 26–27. Distribution of *Peripatopsis capensis* (Grube, 1866) and *P. alba* Lawrence, 1931, in South Africa. 27. Detail of Cape Peninsula showing collection localities for *P. capensis* (squares) and *P. alba* (star). Collection dates: pre-1920 = ▨; 1920–1960 = ☐ ; 1960–present = ■. Areas demarcated are Signal Hill (the smaller area) and Table Mountain.

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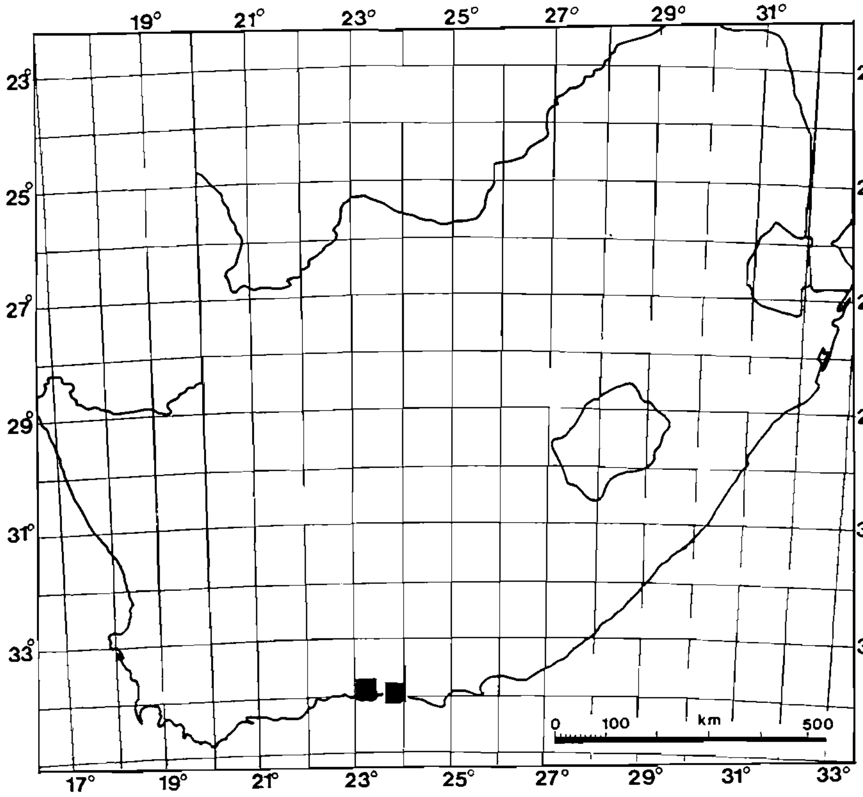

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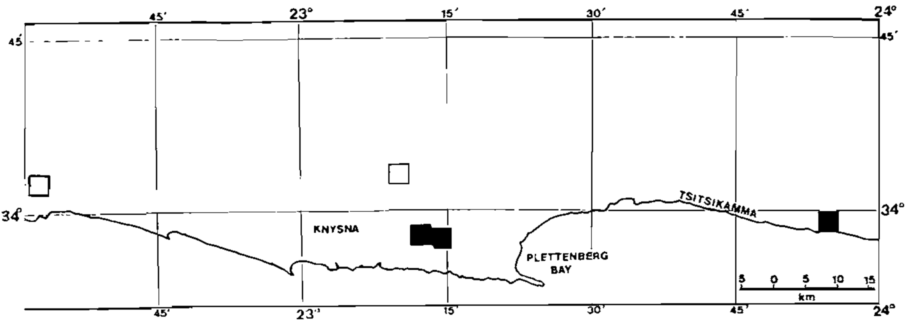

Figs 28–29. Distribution of *Peripatopsis clavigera* Purcell, 1899, in South Africa. 29. Detail of collection localities. Collection dates: 1920–1960 = □ ; 1960–present = ■.

Habitats: Collected from rotten logs and in humus. *P. clavigera* often occurs sympatrically with *P. sedgwicki*, but is usually less abundant than this species. The reverse situation was found at the Harkerville State Forest by Hofmann (1988).

Peripatopsis leonina Purcell, 1899

Figs 22, 30

Description: Size range (mm): length – female 7–41, male 7–34; width – female 2–4, male 2–2.8. Colour: live specimens: greenish-black to black dorsally with 5 longitudinal dark stripes similar to those of *P. balfouri*. Speckling resulting from orange, apically black main papillae. Ventrum pink, often with dark green papillae. Ventral surface of legs and spinous pads coloured as in *P. balfouri*. Legs: Male and female with 20–24 pairs of clawed legs (21–22 most common), 3 foot pads, middle one 2.2–3.0 times as broad as proximal pad. Last pair of legs reduced to same extent as in *P. balfouri* (Fig. 30).

Behaviour: Reported to curl up in a spiral (Lawrence 1953).

Distribution: This species has only been recorded from the type locality of Lion's Hill (Signal Hill), Cape Peninsula (1900) (Fig. 22). Details of the collection localities were given as follows: 'the Cape Town side of Signal Hill; two small valleys cutting into the south-east slopes of that part of Lion's Hill known as the 'Saddle' – the lower portion lying between Lion's Head and Lion's Rump; and from another valley, situated on the same side of the hill but much nearer Table Bay, and east of the signal station on the highest point of Lion's Rump'.

Habitat: Specimens were collected from under stones in small ravines during the winter months. There are no records of *P. leonina* subsequent to the early 1900's. Signal Hill underwent great changes, including the development of recreation areas, the planting of pine forests and the building of houses soon after the discovery of *P. leonina*.

Peripatopsis moseleyi (Wood-Mason, 1879)

Figs 32–33

Description: Size range (mm): length – female 11–75, male 9–50; width – female 1–7, male 1–6. Colour: variable. Two most common patterns either: a) dorsal surface dark, olive green or smoky blue, with lighter lateral band above legs and terracotta main papillae, or b) terracotta or brick-red dorsal surface with a dark green midline, lighter lateral band above legs similar to first pattern and dark green main papillae. Ventrum white or flesh-coloured. Occasional specimens with creamy white, or more rarely a vivid blue, collar encircling the head just behind the antennae (Fig. 3) (these from Creighton and Ixopo). Legs: Male 20–24 pairs clawed + 1 pair unclawed, female 19–23 pairs clawed + 1 pair unclawed. 3 pads, middle one 2–2.2 times broader than proximal pad. Fourth pad may be present. Last pair of legs rudimentary, usually represented only by cluster of papillae and with claws and pads completely missing (Fig. 32). Integument: Main integumentary papillae flat and broad-based or conical.

Distribution: *P. moseleyi* occurs in the forests of the Eastern Cape and between the altitudes of 60–1500 m in KwaZulu-Natal (Fig. 33). The type locality was given only as 'L'Afrique australe, aux environs de Williamstown' and is presumably King William's Town in the Eastern Cape.

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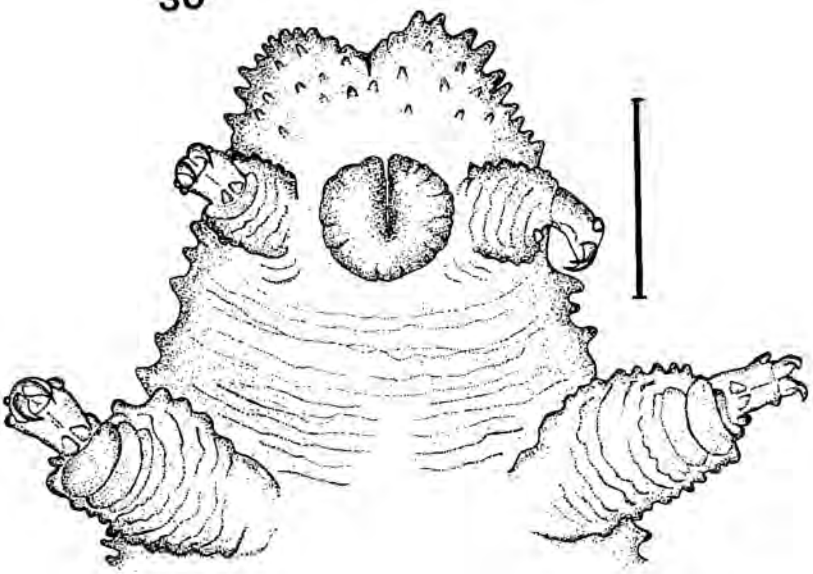

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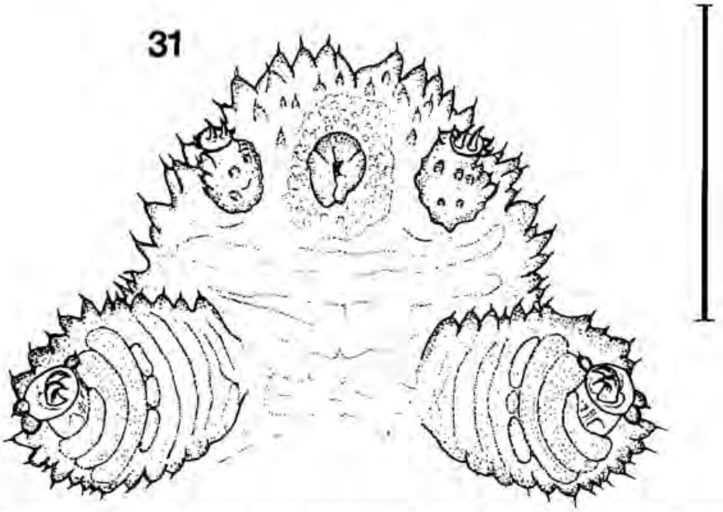

Figs 30–31. *Peripatopsis* species, ventral view, posterior region of body. 30. *P. leonina* Purcell, 1899. 31. *P. sedgwicki* Purcell, 1899. [Scale lines = 1mm].

Localities: **Eastern Cape**: Hogsback (1971); Katberg Forest (1961); Pirie Forest (1907); Port Elizabeth vicinity (1907). **KwaZulu-Natal**: Balgowan (1910); Cedara area (1996); Creighton State Forest (1996); Dargle district: between Lion's River and Impendle (1978), Lion's River (1978); Drakensberg: Bergville district (1960), Cathedral Peak, Ndumeni (1980), Underberg (1973); Durban (1974); Howick, Midmar Dam (1975); Impendle (1947); Impolweni (1928); Karkloof: Nature Reserve

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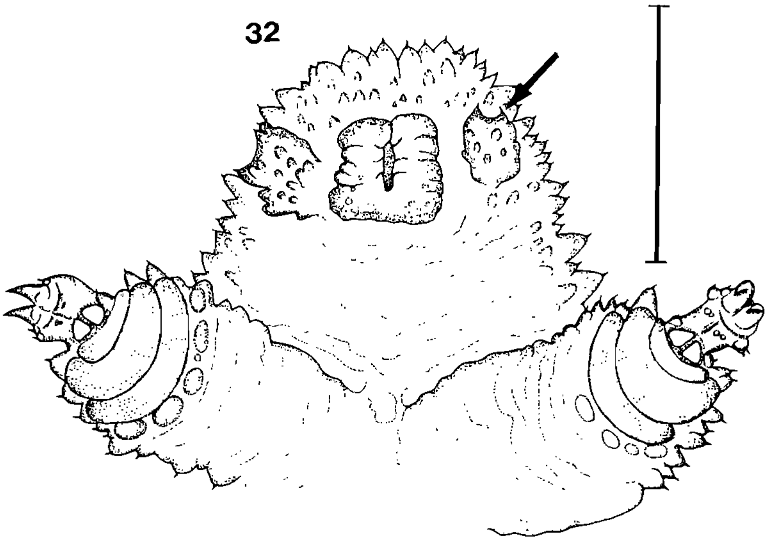

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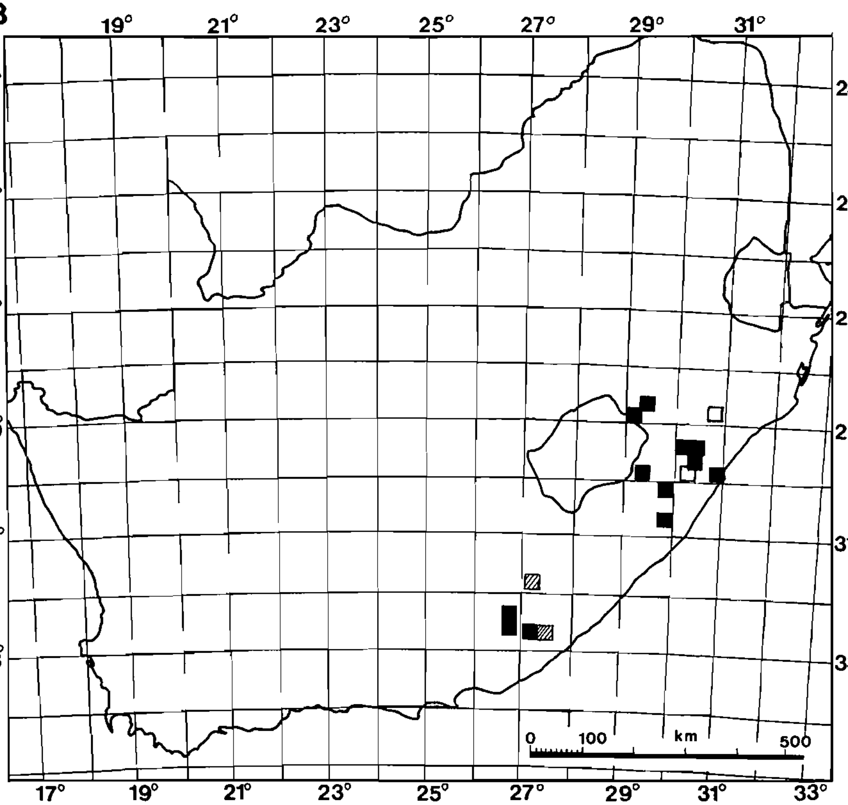

Figs 32–33. Characters and distribution of ***Peripatopsis moseleyi*** (Wood-Mason, 1879). 32. Ventral view, posterior region of body showing last pair of clawed legs and pair of rudimentary, unclawed legs (indicated by arrow) on either side of genital opening. [Scale line = 1 mm]. 33. Distribution. Collection dates: pre-1920 = ▨; 1920–1960 = □ ; 1960–present = ■.

(1995), Farms Hamilton and Shawswood (1978); Kranskop (1997); Pietermaritzburg: Hilton Rd (1957), Moreland Rd (1972), Shooters Hill, Ottos Bluff (1962), Swartkop (1957), Town Bush (1997), Winterskloof (1995), World's View (1986); Richmond (1952).

Habitats: *P. moseleyi* has been reported from a wide variety of habitats including indigenous forest in the Eastern Cape and KwaZulu-Natal, grassland in the Drakensberg, pine and wattle forest, and suburban gardens. Specimens are most commonly found under stones or in rotting logs.

Peripatopsis sedgwicki Purcell, 1899

Figs 31, 34

Description: Size range (mm): length – female 12–68, male 10–46; width – female 2–8, male 1.5–5. Colour: live specimens: blue-grey dorsum, 3 dark grey longitudinal stripes and orange speckles. Ventrum greyish pink. Alternatively, dorsum with ground colour of grey-green, olive, blue-green or yellow-green. Preserved specimens: Greenish black with 3 orange-brown stripes and orange speckles, or orange-brown with green stripes and green speckles. Legs: Male and female with 20 pairs of clawed

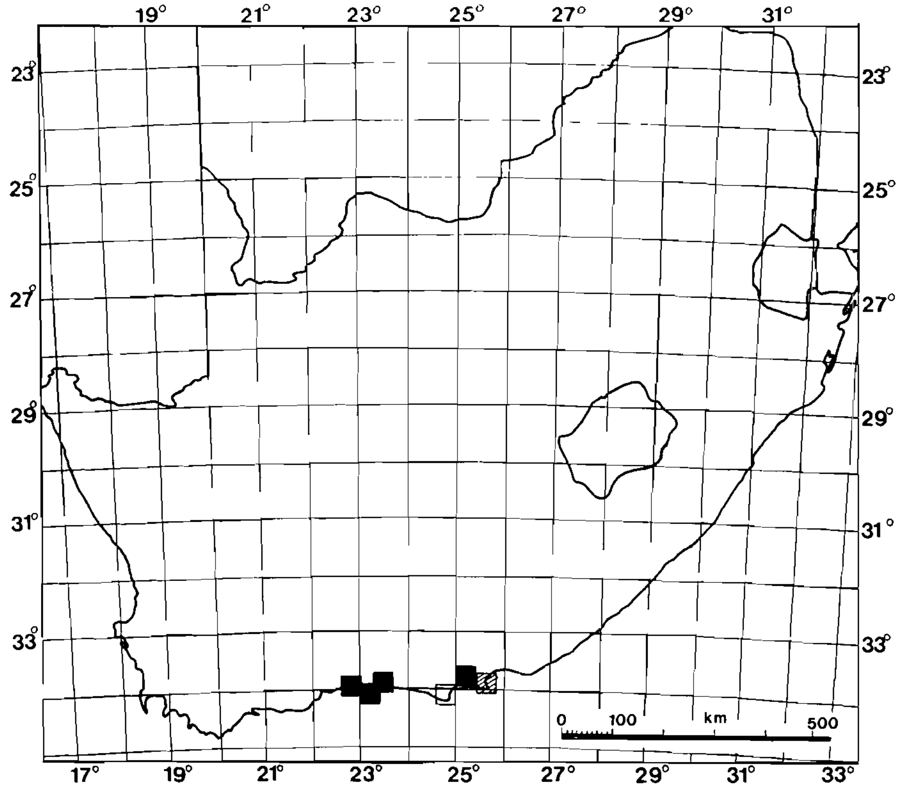

Fig. 34. Distribution of *Peripatopsis sedgwicki* Purcell, 1899. Collection dates: pre-1920 = ▨; 1920–1960 = ☐; 1960–present = ■.

legs. 3–4 pads, middle spinous pad not very broad, 1.5–2.5 times as wide as proximal pad. Last pair of legs reduced (to a greater extent in male), but foot with distinct claws (Fig. 31). Integumentary papillae: Bluntly or sharply conical.

Behaviour: Does not curl up in a spiral.

Distribution: *P. sedgwicki* has a limited distribution and has only been recorded from the Knysna and Grahamstown regions of the Eastern Cape (Fig. 34).

Localities: **Eastern Cape**: Grahamstown, Rabbits Wood (1956); Groot Gamtoos River (1957); Port Elizabeth (1900*); Storms River Mouth area (1964); Tsitsikamma Forest: Bloukranz River (1951), Forest Inn (1951); Van Stadens Pass (1957); Witelsbos (1928). **Western Cape**: Diepwalle Forest Reserve (1985); Garden of Eden (1975); Knysna: farms near the town (type locality) (1899*), 10 miles from Knysna on road to Avontuur (1938); Kranshoek, Harkerville district (1984); Millwood (1938); Plettenberg Bay (1899).

Habitats: The type series was collected from rotten wood in the forest and under weed heaps on farms near Knysna. Other data from material collected in 1951 (Brinck 1957) includes: 'collected in rotten logs and under decaying wood in indigenous forest, a few of them creeping on meadow at the edge of the forest in rainy weather' and 'among stones in ravine near the river'. Brinck (1957) noted that *sedgwicki* is comparatively abundant in the area of its distribution, and occurs in large numbers, particularly in the indigenous forest of the Tsitsikamma Mountains. Hofmann (1988), however, found only a few specimens of this species in the Kranshoek forest.

SYNONYMS

Peripatopsis intermedia Hutchinson, 1928

Only the holotype of this species, from 12 km E. of Montagu, is known. The validity of this nominal species is doubtful and Ruhberg (1985) synonymised it with *P. balfouri*.

Peripatus brevis Blainville, 1836

Both Brinck (1957) and Ruhberg (1985) stated that *P. brevis* is probably a synonym of *P. capensis*. This cannot, however, be confirmed since the original description is erroneous and incomplete, and the unique holotype is lost. *Peripatus brevis* was described as having only 14 pairs of legs. No specimens with this number of legs were subsequently found on Table Mountain (the type locality), and so *P. brevis* can be considered as either a synonym of *P. capensis* or as a *nomen dubium* (Ruhberg 1985).

UNDESCRIBED SPECIES

Manton (1938*a*) briefly described, but because of the poor quality of the specimens, did not name, an additional two *Peripatopsis* species. The first was collected from Knysna forest and near Grahamstown. Its behaviour differed from the species which it resembled (the *balfouri* group) in that it did not curl up spirally. This species was of smallish size and dark grey-black in colour dorsally and laterally, or brown dorsally with a light band above the legs, with a purple ventrum, and with 16 pairs of legs. The second species was collected from Wilderness, near George. Manton (1938*a*) stated that it was a similar size to *P. capensis,* but that its behaviour, and the external appearance of the embryos, indicated its distinctness from other species.

A single male collected from the Tsitsikamma forest near Storms River in 1957 may represent a third undescribed species. Ruhberg (1985) described this specimen as follows: 18 pairs of legs, the last pair with a distinct clawed foot. Dorsally dark green, without speckling and ventrally white. Feet with 4 spinous pads, the middle one 3.5 times as broad as the proximal one. The main integumentary papillae broad based and semi-clavate. Dr M. Walker (Leicester University) and Dr H. Ruhberg are in the process of describing two additional South African species of *Peripatopsis*, one from Table Mountain, and another from Grootvadersbos in the southern Cape. Ruhberg is also currently describing a new species of *Peripatopsis* from Vilanculos on the northern Mozambique coast. This is the first onychophoran record from Mozambique.

CONSERVATION OF SOUTH AFRICAN ONYCHOPHORA, WITH RECOMMENDATIONS

Although the South African species have been well-researched in terms of their biology, anatomy and broad distribution, onychophorans are notoriously difficult to find and their abundance could be related to rainfall as suggested by Manton (1938*a*). This means that there are certainly many unrecorded and undiscovered onychophoran localities. In view of the Australian findings using allozyme analysis and scanning electron microscopy (Ruhberg 1985, Read 1988, Tait & Briscoe 1990), it is highly likely that many cryptic South African species have yet to be identified.

Conservation relative to distribution

As there are very few described South African species, identification of true species-richness and endemism hotspots is not really possible. Nevertheless, there are two areas where congruence is relatively high. The first is the relatively small area of the Cape Peninsula, which supports *P. alba, P. balfouri, P. capensis* and *P. leonina.* The second area is southern and central KwaZulu-Natal, where *Opisthopatus cinctipes, O. roseus* and *P. moseleyi* occur. The northeastern corner of the Western Cape supports the remaining two species, *P. clavigera* and *P. sedgwicki.* More relevant is that the species on the whole have relict distributions, with *O. roseus, P. alba* and *P. leonina* known only from single localities. The only widespread species is *O. cinctipes.* In terms of conservation, each species must be considered individually within its distribution. This approach, in turn, also affords protection of their habitats (see below).

Recommendation: It is essential to determine whether previously recorded localities are still valid, and to investigate possible new localities for the nine known species, as well as those of any new species. Point localities of occurrence of all Onychophora species should be verified, and new point localities determined. This will provide accurate data for GIS.

Threatened species

A restricted distribution does not necessarily mean that a species is threatened, provided that the habitat and its surrounds are secure. The intensity of threat is also relative to the life-history and the sensitivity of the subject taxon. For example, *O. cinctipes* is not only widespread but is also highly tolerant of various land disturbances, and is commonly found in pine plantations and in suburban gardens among exotic plants. In addition, this species reproduces throughout the year. *P. alba,* on the other hand, is truly troglobitic, known only from one cave system, and appears to be highly stenotopic.

The effect of different disturbances on onychophoran populations has not been determined. Lawrence (1980) stated that onychophorans had been fairly plentiful at Fern Kloof and other forested areas in the Grahamstown region, but that 'fire, the worst enemy of peripatus, has no doubt eradicated them here as in other localities'. In the Cathedral Peak area of the Drakensberg, however, onychophorans appear to have survived controlled burning of the grassland habitat over several years.

Recommendation: Four South African species, *Opisthopatus roseus, Peripatopsis alba, P. clavigera* and *P. leonina* should be Red Listed, both nationally and internationally. Threats to their populations should be assessed, so as to refine their Red List categorisation.

TABLE 1

Threatened onychophoran species of South Africa.

Species	**Distribution**	**Most recent record**	**Threats**	**IUCN category**
Opisthopatus roseus	KwaZulu-Natal: Ingeli forest	1995	Habitat alteration and decrease in area through commercial forestry	VU
Peripatopsis alba	Western Cape: Table Mountain, Wynberg cave system	1995	Disturbance by cavers, over-collecting	VU
Peripatopsis clavigera	Western Cape: Notheastern part	1984	No immediate threat	LR-lc
Peripatopsis leonina	Western Cape: Peninsula, Signal Hill	1900	Habitat alteration through urbanisation	CR

Recommended IUCN categorisation

Currently, the South African species which are Red Listed (Groombridge 1993) are: *Opisthopatus roseus* (V), *Peripatopsis alba* (V), *P. clavigera* (R) and *P. leonina* (E). It is now timely to assign the recent Categories of Threat (Mace & Stuart 1994, IUCN 1994) to these four species, which were also identified in this study as being the ones that should be Red Listed.

(a) *Opisthopatus roseus* (VU)

Status: This species appears to be confined to one locality, the Ingeli Forest, KwaZulu-Natal. Its status was uncertain until 1995 when it was rediscovered on two occasions and information about its collection in 1985 became known. Currently, Ingeli Forest is listed as being protected by the Department of Water Affairs and Forestry, and although this should indicate protection of the species' habitat, the indigenous forest is surrounded by commercial forests controlled by SAFCOL. A potential threat to *O. roseus* is the absence of a distinct boundary between indigenous and commercial forest and therefore possible habitat encroachment. Over-collecting is also a potential problem, particularly since the forest is easily accessed from a public road which traverses the forest.

IUCN Categorisation: This species should, in theory, not be truly threatened at present. The extent of protection afforded Ingeli Forest is, however, uncertain. *Opisthopatus roseus* does fulfil at least two of the criteria required to be categorised as 'Vulnerable' (V): it could face a 20 % reduction in population through a reduction in its habitat area or habitat quality through commercial forestry, it has a restricted range (probably less than 100 km^2) and it occurs in a single locality.

(b) *Peripatopsis alba* (VU)

Status: This species is only known from the Wynberg Cave system. It is extremely scarce in these caves, and probably has a small total population. Although the caves are protected, they are increasingly subject to more disturbance from cavers. Entry to the caves should be restricted.

IUCN Categorisation: As this species has a very small range (<100 km^2) and is known only from one locality, it is prone to the effects of human activities which could cause it to become 'Critically Endangered' or 'Extinct' within a very short period. It is thus categorised as 'Vulnerable' (VU).

(c) *Peripatopsis clavigera* (lc)

Status: This species occurs in some of the forests in the southern Cape. Although these forests have, in the past, been reduced, they are largely protected. This species, although apparently a habitat specialist, appears to be relatively safe.

IUCN Categorisation: This species falls under 'Lower Risk'. It does not appear to be 'Near Threatened', and qualifies as 'Least Concern' (lc), at least at present.

(d) *Peripatopsis leonina* (CR)

Status: Despite intensive searches, this species has not been reliably rediscovered for over 90 years. The outlook is bleak, as its type locality has been directly or indirectly substantially changed by urbanisation.

IUCN Categorisation: There could possibly still be some optimism for its survival, especially as onychophorans can be so cryptic. Optimistically, as it probably has an area of occupancy of <100 km^2 *and* its population occurs at a single location *and* there is a continuing decline in area/extent and/or quality of habitat, the category 'Critically Endangered' (CR) applies.

(e) Other species

Two of the five species not listed above (*O. cinctipes* and *P. moseleyi*) have relatively wide distributions. Populations currently included in these species could prove to be separate species when examined using additional taxonomic techniques, and some of these species may fit the Red Data List criteria. This fact should be taken into consideration in conservation of the group. Also, the five undescribed species identified to date all have restricted ranges, and are possibly additional Red List candidates. Rapid rate of development (both agricultural and urban) could also change the current status of the other unlisted species.

Conservation management

Probably the best protection for these Onychophora species is to maintain their habitats intact (see also Mesibov & Ruhberg 1991). These animals are notoriously difficult to sample, making ongoing censuses very difficult and impractical. This means that once found in an area, at best, they could be periodically searched for again to ascertain whether they are still present. But not finding them does not mean that they are necessarily absent. Intensive searches in other areas are also likely to yield not only new population records, but possible new species as well.

Captive breeding at this stage does not appear to be warranted for the threatened South African species. However, as New (1995) points out, captive breeding of the more common and less threatened species may satisfy the 'teaching material' trade. Indeed, over-collecting does appear to pose a genuine threat to onychophoran populations, as they are often so localised and apparently with low population numbers.

Recommendations: All the threatened species, with the exception of *P. leonina*, occur in officially protected areas. Their status should be periodically (approximately every five years) reassessed for IUCN re-categorisation. Conservation management involves maintaining their habitats intact. The effectiveness of this type of management, and the most recent level of threat should also be periodically reassessed.

Legal protection

Onychophora species – at least the known threatened ones – are invertebrates that are likely to benefit from legal protection, as their localities are restricted and can be monitored effectively.

Recommendations: All Onychophora species, with the exception of *O. cinctipes*, should be legally protected in South Africa. Collecting permits should only be issued to *bone fide* researchers. Even these permits should restrict collection of *P. alba* and *P. leonina, O. clavigera* and *O. roseus*. No more than two adults of any species should be collected from any one locality. Exceptions would be *O. cinctipes, P. balfouri* and *P. capensis*, because they are more common and over-collecting does not appear to be a threat. Nevertheless, collecting permits should limit the total numbers of individuals of these three species to be collected. At the other extreme, there should be a complete collecting ban (except for very special scientific purposes) on *P. alba* and *P. leonina*, as they are so scarce and threatened.

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